The Special Relationship Between *Nepenthes* and Tree Frogs

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We have been observing the wild *Nepenthes mirabilis* for eight years in the valley in Zhuhai City, Guangdong Province, The People's Republic of China, and have discovered a special relationship between *Nepenthes* and tree frogs.

When we first saw a living frog in the pitcher of the *Nepenthes*, we thought that the frog was trapped and captured (see Figure 1). When we first touched the plant's pitcher, the first reaction of the frog was to rapidly dive into the digestive juice with its eyes shut. After a period of tranquility, the frog stuck its head out of the juice and groveled on the inner side of the wall of the pitcher. It seemed that the frog was not going to wait helplessly for the end of its life, but was as comfortable as if in its own "home" or shelter. While we were taking pictures, we cut a hole in the wall of the pitcher. While fluid drained out, the frog did not try to flee. Only when we forced it out of the pitcher with a small tree branch, did it jump out through the hole we had cut.

What on earth is the relationship between *Nepenthes* and tree frogs? And how do the tree frogs enter the pitcher?

In order to solve the mystery we searched for another pitcher with a frog in it. We found a pitcher containing a frog, but we did not disturb it. When we revisited the pitcher the next day, the frog had disappeared. Obviously, the frog left the pitcher by itself

The third time we saw a frog in a pitcher we were ready with an experiment. We dangled into the pitcher a pebble on a fine thread. This was intended to mimic an insect foraging for food near the entrance of the pitcher. All of a sudden, the frog jumped from the lower part of the pitcher, caught the pebble, immediately spat it out when it found it was not a prey, and returned to the bottom of the pitcher. This time it went deep into the juice to hide itself. After a while when we shook the pebble again at the entrance of the pitcher, the frog tried to go deeper into the juice (see Figures 2, 3). Ten minutes later we came back, but the frog in the pitcher was gone. How did it get out?

The fourth time we found a frog in a pitcher, we waited patiently to watch what it was doing. The frog stayed on the inner side of the wall without any movement. Suddenly a small insect flew over the entrance, the frog jumped up and caught it. We forced it out with a small tree branch but it crawled slowly out of the pitcher into the grass. It seemed that it came out against its own will (see Figure 4).

The fifth time when we found a frog in a pitcher, we wanted to take pictures of how it got out of the pitcher. We focused the camera and waited a long time but the frog did not move. We could do nothing but try to lure and disturb it to see if it could jump out of the pitcher .When we again used the method of mimicking an insect at the entrance, the tree frog drew back into the juice. When we no longer disturbed it, it crawled up to the upper part of the pitcher, waiting. Finally we knocked the pitcher with a small tree branch, the frog at last jumped out of the pitcher. Fortunately we succeeded in taking pictures of how the frog was jumping out. But we did not use a professional video camera and the movement of the frog jumping out of the pitcher was no more than a blurry contrail.

Through the five observations, we can draw several conclusions. First, the *Nepenthes* pitcher cannot capture tree frogs. The frogs can easily move in or out of the digestive fluid, and can easily climb the pitcher walls. They can easily enter or exit the pitchers. Second, the fluid in the pitchers, which can digest insects, has no harmful effect on the skin of the tree frogs. That the frogs can withstand the digestive juices is remarkable to us, because we measured the acidity of many pitchers and found the pH in them was as low as 2. How they withstand the digestive juices deserves additional research. The mucilage (probably a complex mixture of oligosaccharides) produced by the skin of the frog is probably a sufficient barrier to the acids and enzymes present in the pitcher fluid, and only water can enter this protective coat (J. Schlauer, pers. comm.). In fact, the digestive juice provides a good, wet habitat for these amphibians.

The tree frogs in *Nepenthes* pitchers are not captured organisms awaiting their doom, but instead are "waiting for windfalls." The honey on the entrance of the pitcher lures many small insects, which the frogs wait for. It is not only an easier way for them to capture insects but also reduces the danger of being captured for food by their predators. Tree frogs seem to live a parasitic life in the pitcher of the *Nepenthes*, or may even be partners with the plants.

The relationship between living creatures is more complicated than we can imagine. The mutual dependence, interactions, relationships, and co-evolution are of special significance in the maintenance, stabilization, and balance of the biogeocenose.

It is necessary for us to preserve these plants and their habitats to make a deep study of them.

Figure 1: A hole was cut on the wall of the pitcher but the tree frog did not try to come out.

Figure 2: We shook a pebble tied by a fine thread to mimic an insect coming to the entrance of the pitcher.

Figure 3: The frog at the bottom jumped onto the entrance to catch the pebble.

Figure 4: We forced the tree frog out of the pitcher into the grass. It seemed that it came out against its own will.